

Claims

1. Signal processing device including a signal transformation module (5) capable of producing a transformed signal (xi) from an original signal and a mixing module (10) intended to mark the transformed signal by a marking message (M), characterised in that the mixing module (10) includes:
- a formatting module (14) capable of calculating a response of the transformed original signal (rx) to the demodulation of a first set of carriers (G_j) defined by keys protecting the message, and of calculating a marking information ($\{b_j\}$) based on this response and code words (U) associated with the marking message,
 - a modulator (18) capable of modulating the marking data supplied by the formatting module (14) with a given coefficient (G_{ij}) of the carriers of the first set of carriers, and of modulating in amplitude the resulting coefficient by a corresponding quantity related to the energy weighting term of the marking message and to the set of carriers, thereby supplying a marking coefficient,
 - an adder (20) capable of adding the marking coefficient to the corresponding coefficient of the transformed original signal.
2. Device according to Claim 1, characterised in that the formatting module (14) includes a demodulator (15) intended to perform the demodulation, said demodulator being capable of multiplying each coefficient of the transformed original signal (xi) by the corresponding coefficient of a given carrier (G_{ij}) in the first set of carriers, by the perceptual weight of distortion (φ_i) and by the attenuation factor (γ_i) associated with said coefficient of the transformed signal, and to add the coefficients thus determined, thereby supplying a component of the response of the transformed original signal.
3. Device according to any of the foregoing claims, characterised in that the formatting module (14) is capable of calculating the marking information from a predetermined parameter (θ), a first vector (U_k) associated with a particular code word of the marking message and a second vector forming in conjunction with said first vector a normalised orthogonal base defining a hyperplane.
4. Device according to Claim 3, characterised in that the particular code word (U_k) is obtained by minimising a quadratic error criterion between the code words associated

with the marking message and the normalised value of the response of the transformed signal (rx) to the demodulation.

5. Device according to either of Claims 3 and 4, characterised in that each component (V_j) of the second vector is proportional to the difference between the corresponding component of the response (rx_j) to the demodulation and the projection of the vector representing the response to the demodulation (rx) on a unit vector colinear with the first vector ($U_k/\|U_k\|$).

6. Device according to any of Claims 3 to 5, characterised in that the predetermined parameter (θ) corresponds to the angle between the vector representing the marking information ($\{b_j\}$) and the first vector (U_k), this parameter (θ) being determined by maximising the relationship:

$$K.(u_o + \cos \theta)^2 - (v_o + \sin \theta)^2$$

in which:

- u_o represents the scalar product between the vector representing the response to the demodulation (rx) and the first vector, divided by the number m of components of the response to the demodulation,

- v_o represents the scalar product between the vector representing the response to the demodulation (rx) and the second vector (V), divided by the number m ,

- $K = 1/(2^{2(C+R)m}-1)$, C and R respectively denoting the number of useful bits and adaptation bits to the original signal, and m denotes the number of components of the demodulation response (rx).

7. Device according to any of the foregoing claims, characterised in that the mixing module (10) includes a carrier generating module (16) capable of generating the first set of carriers from keys protecting the message (M).

8. Device according to any of the foregoing claims, characterised in that the mixer includes a scaling module (17) capable of modulating in amplitude each signal coefficient supplied by the adder circuit (20) by a quantity related to the energy weighting term of the marking message (σ_{wi}) and the variance (σ_{xi}^2) of the corresponding coefficient of the transformed original signal (xi).

9. Device according to Claim 8, characterised in that said quantity is defined by $\sigma_{xi}^2 / (\sigma_{xi}^2 + \sigma_{wi}^2)$, where σ_{xi}^2 is the term defining the energy of the marking message and σ_{xi}^2 is the variance of the corresponding coefficient of the transformed original signal (xi).

5 10. Device according to any of the foregoing claims, characterised in that it includes an inverse transformation module (6) at the output of the mixer (10), capable of performing an inverse transformation on the marked signal relative to that performed by the transformation module (5).

10 11. Device according to Claim 10, characterised in that it includes an extraction device (2) at the output of the inverse transformation module (6) to extract the message from the marked signal, the extraction device including a resynchronisation module (8) capable of resynchronising the marked signal and a signal transformation module (7) capable of transforming the resynchronised marked signal, thereby supplying a transformed marked signal (yi').

15 12. Device according to Claim 11, characterised in that the transformation performed by the transformation module (7) of the extraction device is identical to that performed by the transformation module (5) to provide the coefficients of the transformed original signal.

20 13. Device according to either of Claims 11 and 12, characterised in that the extraction device (2) is capable of calculating a response of the transformed marked signal (yi') to the demodulation of a second set of carriers (Gj) defined by message protection keys, thereby providing an estimate of the marking information inserted (\hat{b}_j).

14. Device according to Claim 13, characterised in that the first set of carriers and the second set of carriers are identical.

25 15. Device according to any of Claims 11 to 14, characterised in that the extraction device (2) includes a demodulator (21) intended to perform the demodulation, said demodulator being capable of multiplying each coefficient of the resynchronised marked signal (yi') by the corresponding coefficient of a given carrier (Gij) of the second set of carriers and by the perceptual weight of distortion (ϕ_i) associated with said coefficient of the resynchronised marked signal, and of adding the coefficients thus

determined, thereby providing a component of the estimate of the marking information (\hat{b}_j).

16. Device according to any of Claims 11 to 15, characterised in that the extraction device (2) includes a carrier generating module (16) capable of generating the second set of carriers from keys protecting the message (M).

17. Device according to any of Claims 11 to 16, characterised in that the extraction device (2) includes a decoder (22) capable of determining the code word closest to the estimate of the marking information (\hat{b}_j) by maximising a quadratic error criterion between a set of code words and the marking information estimate, thereby providing the marking message.

18. Device according to any of the foregoing claims, characterised in that it includes an insertion parameters definition module (13) at the input to the mixing module (10) capable of determining the energy weighting term of the marking message (σ_{wi}) and the attenuation factor (γ_i) based on the intrinsic properties of the signal, the application domain constraints, and the properties of the transformation used.

19. Device according to Claim 18, characterised in that the insertion parameters definition module (13) is capable of calculating two global insertion parameters (λ, χ) in relation to the insertion distortion D_{xy} between the original signal (x) and the marked signal (y) in the transform space, the maximum allowable attack distortion $D_{xy'}$ between the original signal (x) and the resynchronised marked signal (y') in the transform space, and the signal to noise ratio between the energy of the marking message and the attack noise E_b/N_0 .

20. Device according to Claim 19, characterised in that the two global insertion parameters (λ, χ) are calculated by searching for the parameters λ and χ which maximise the relationship: $E_b/N_0 + \lambda D_{xy'} - \chi D_{xy}$.

21. Device according to Claim 20, characterised in that the insertion parameters definition module (13) is capable of calculating the energy weighting term of the marking message (σ_{wi}) and the attenuation factor (γ_i) from two determined global insertion parameters (λ, χ).

22. Device according to any of the foregoing claims, characterised in that the coefficients of the transformed original signal (xi) supplied by the signal transformation module (5) are those of a Fourier transformation.

5. 23. Device according to any of Claims 1 to 21, characterised in that the coefficients of the transformed original signal (xi) supplied by the signal transformation module (5) are those of a cosine transformation.

24. Device according to any of Claims 1 to 21, characterised in that the coefficients of the transformed original signal (xi) supplied by the signal transformation module (5) are those of a wavelet transformation.